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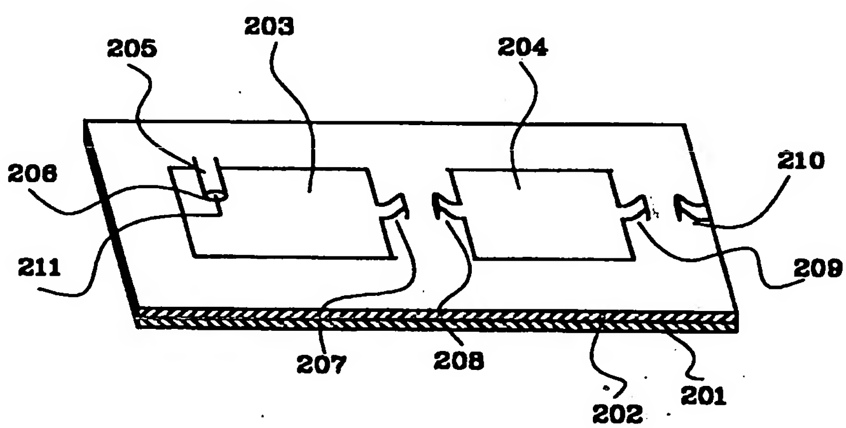
(54) Title: TRAP MICROSTRIP PIFA



(57) Abstract

The present invention relates to a small microstrip antenna device, mountable inside a hand-held radio communication device, for receiving and transmitting RF signals in one or more frequency bands. The microstrip antenna comprises a ground plane means (101), at least a first feeding means (107) and N radiating elements where N is an integer greater than zero. Said microstrip antenna structure having a first conductive patch (104). Said feeding means being arranged on said first patch for feeding radio frequency signals to said N radiating elements, at least a first of said N radiating elements having a second patch (106). Said second patch being inductively coupled (108) to the first patch.

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TRAP MICROSTRIP PIFA

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on the Swedish patent application SE 9702659-5 'Compact Antenna Device' which is hereby incorporated by reference and the international patent application PCT/SE98/00899 'Compact Antenna Device' which is hereby incorporated by reference. Both are having the same applicant as the present invention.

TECHNICAL FIELD OF INVENTION

The present invention relates in general to an antenna structure and more specifically to a microstrip antenna structure.

DESCRIPTION OF RELATED ART

With the recent advances in mobile communication, there has been tremendous interest in development of small size and low profile antennas for the further miniaturization of mobile radio communication equipment. Goals include small size, low profile, low cost and ease of manufacturing. Frequencies of interest can for instance be 900 MHz band antennas for applications in cellular handheld radio devices such as GSM (890-935 MHz), indoor cordless telephones such as the European CT1+ (886-931 MHz) and 1.9 GHz band antennas for applications in DECT (1.89 GHz) and PCS (1.8 GHz). These systems have their own requirements in antenna characteristics, such as resonant frequency, bandwidth, gain etc.

Existing antennas used in mobile phones include the most common whip antennas (monopole), microstrip patch antennas and planar inverted-F antennas. Microstrip patch antennas and planar inverted-F antennas are typically low-profile antennas. Although the microstrip patch antenna previously has had the shortcoming

of narrow bandwidth and low efficiency, its advantages of low profile, small size and light weight are attractive properties.

However both planar inverted-F antennas and microstrip patch antennas exhibits size problems when they should be adjusted for the specific frequencies and fit into the newer generation of miniature mobile radio communication devices. This is particular problematic when modern mobile phone design calls for multiple antennas to be placed into one handset to be able to simultaneously communicate in two different systems, in a very broad frequency band or more generally to take advantage of antenna diversity.

EP 749 176 'Planar and non-planar double C-patch antennas having different aperture shapes' discloses a patch antenna. The C-patch antenna includes a truncated ground plane, a layer of dielectric material having a first surface overlaying the ground plane and an opposing second surface, and an electrically conductive layer. The conductive layer forms a radiating patch and has a non-rectangular aperture.

WO 96/27219 'Meandering inverted-F antenna' discloses an inverted F-antenna with a meandering pattern. The antenna is a planar radiating structure having alternating cutouts along a longitudinal dimension of a planar radiating element or patch which is parallel to a nearly coextensive ground plane.

SUMMARY OF INVENTION

The object of the present invention is thus to achieve a small microstrip antenna device, mountable inside a hand-held radio communication device, for receiving and transmitting RF signals in one or more frequency bands.

The problems described above, with how to achieve an antenna which is mountable inside and hand-held radio communication device is solved by providing a microstrip antenna comprising

a ground plane, at least a first feeding means and N radiating elements where N is an integer greater than zero. Said micro strip antenna structure having a first conductive patch. Said feeding means being arranged on said first patch for feeding radio frequency signals to said N radiating elements, at least a first of said N radiating elements having a second substantially rectangular patch. Said second patch being inductively coupled to the first patch and, said second patch having a free end.

In more detail the objects of the present invention according to one embodiment, is achieved by providing the above mentioned microstrip antenna structure wherein at least one of said N radiating elements having a capacitive coupling to ground in said free end.

In more detail the objects of the present invention according to one embodiment, is achieved by providing the above mentioned microstrip antenna wherein, said first and second patch being thin conductive layers on a dielectric substrate. Said substrate comprising at least first and second protrusions arranged for retaining a component in electric contact with said first and second patch.

An advantage with the present invention is that a small microstrip antenna structure is achieved which is suitable for mounting inside a hand-held radio communication device.

Another advantage with the present invention is that said antenna structure can be tuned to be responsive to multiple frequencies.

An advantage, according to one embodiment of the invention, is that the antenna structure can be achieved with a choice of using discrete components or not.

An advantage, according to one embodiment of the invention, is that the antenna structure may be implemented directly on the

inside of a back cover of a hand-held radio communication device.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings, which are given by way of illustration only, and thus are not limitative of the present invention and wherein,

figure 1 shows a schematic, perspective view according to a first preferred embodiment of the invention,

figure 2 shows a schematic, perspective view according to a second preferred embodiment of the invention,

figure 3a, 3b and 3c shows schematic views of a retainer arrangement according to a preferred embodiment of the invention,

figure 4 shows a diagrammatic view according to the second embodiment of the invention,

figure 5 shows a diagrammatic view according to a third embodiment of the invention,

figure 6a, 6b shows diagrammatic views of different variants according to a fourth embodiment of the invention,

figure 7a, 7b, 7c, 7d shows diagrammatic views of different variants according to the fourth embodiment of the invention,

figure 8a, 8b, 8c shows diagrammatic views of different variants according to a fifth embodiment of the invention,

figure 9a, 9b shows diagrammatic views of different variants according to a sixth embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows a schematic, perspective view according to a first preferred embodiment of the invention. A ground plane is denoted 101 and applied to the backside of a printed circuit board 102. A dielectric substrate is denoted 103 and is acting as a carrier for a radiating structure 104. The radiating structure 104 is, in this preferred embodiment, a conductive pattern, which can be achieved with for instance MID-technique (Molded Intrusion Design) which is a technique well known to the skilled man in the art. Another possibility is to use a conductive pattern, screen printed on an adhesive flexible film.

The radiating structure 104 comprises a first patch 105 and a second patch 106. The first patch 105 comprises feeding means 107 for feeding an RF signals to the radiating structure. The first patch 105 is connected to the second patch 106 through a meandering pattern 108. The meandering pattern 108 acts as a inductive connection between the first and second patches 105 and 106. The inductance is determined by the number of turns and the width of the meandering pattern 108. The second patch 106 is folded over the edge 109 and continues towards the ground plane 101 to effectively achieve a capacitive coupling between the second patch 106 and the ground plane 101. A capacitive coupling is, of course also existing between the first patch 105 and the second patch 106 and the conductance is determined by the distance between the two patches.

Figure 2 shows a schematic, perspective view according to a second embodiment of the invention. A ground plane is denoted 201 and a dielectric substrate is denoted 202, a first patch is denoted 203 and a second patch is denoted 204. A feeding means in the form of a coaxial cable is denoted 205. The shield of the coaxial cable is connected to the first patch 203 at a first connection point 206 and the feed of the coaxial cable is connected to the first patch 203 at a second connection point 211. The distance between the first and second connection point is determining the input reactance. The dielectric substrate comprises first, second, third and fourth protrusions denoted 207, 208, 209 and 210, respectively. The first patch 203 comprises a conductive strip folded over the first protrusion 207 and the second patch comprises a conductive strip folded over the second protrusion 208. The first and second protrusions are arranged for retaining a discrete component, such as for instance a coil or more generally an inductance, in electrical contact with said first and second patch. The discrete component is not shown in figure 2 for sake of clarity. The protrusions are somewhat flexible or resilient so a contact force is established between the folded strip and the discrete component on respective side. It is of course also possible to solder the discrete component to achieve even better retaining capabilities.

The second patch 204 comprises a second conductive strip folded over the third protrusion 209 and the ground plane also comprises a conductive strip folded over the protrusion 210. Thus can a discrete component, such as a capacitor (not shown), be retained between the third and fourth protrusions in electric contact with said second patch 204 and the ground plane 210.

Figure 3a, 3b and 3c shows schematically in a closer view different variants of the retainer arrangement in figure 2. In figure 3a is a discrete component, such as a coil, active

inductor, tunable inductor or other inductive means, denoted 301. The first patch 203 with the conductive strip folded over the first protrusion 207 is soldered to the component 301. The second patch 204 is folded over the second protrusion 208 and soldered to the component 301.

In figure 3b is a different retainer arrangement disclosed where the resilient or flexible characteristics of the dielectric substrate are fully used. In this embodiment, no soldering is required. When the discrete component 302 is pushed down in the retainer the first and second protrusion 303 and 304 flexes back so as to let the component 302 to pass. Once the component is in the retainer the protrusions resumes their original positions effectively retaining the component 302 through the small cutouts in the protrusions. In figure 3b, a ground plane 305 is folded over an edge and again over the second protrusion 303 to achieve electrical contact between the ground plane 305 and the component 303.

In figure 3c is the electrical contact between a component 305 and a ground plane 307 achieved through a connector means 308.

Figure 4a shows a first diagrammatic view and figure 4b a second diagrammatic view according a preferred embodiment of the invention. A first patch is denoted 401, a second patch is denoted 402 and an inductive coupling between the first and second patch is denoted 403. A first capacitive coupling between the second patch and ground is denoted 404 and a second capacitive coupling between the first and second patch is, in figure 4b, denoted 405. A signal generator is denoted 406 and a ground connection is, in figure 4a, denoted 407. The radiating structure is adjusted to have first resonance frequency f1 for which the inductance 403 and the second capacitance 405 effectively acts as a open circuit where substantially only the first patch is radiating RF signals. For a second resonance

frequency f2 the inductance 403 and the second capacitance 405 effectively acts as a short circuit and substantially both the first and second patch radiates RF signals as one antenna element. Thus, the combined inductive and capacitive coupling between the first and second patch act as a trap preventing signals within a specific frequency band to pass the coupling. Even though not shown in figure 4, it is of course possible to have a discrete capacitive component to attain the capacitive coupling between the first patch 401 and the second patch 402. This can for instance be achieved as described in combination with fig. 2.

Figure 5a and 5b shows diagrammatic views according to a third preferred embodiment of the invention where no top capacitance is used.

Figure 6a and 6b shows diagrammatic views according to a fourth embodiment of the invention. A first patch is denoted 601 having first and second protruding parts 602 and 603 respectively. Feeding means for feeding RF signals to the radiating structure is denoted 604 and a ground feed is denoted 605. A second patch is denoted 606 and a third patch is denoted 607. The second patch is coupled through a first inductance 608 to the first protruding part 602 and the third patch 607 is coupled through a second inductance to the second protruding part 603. Thus is two separate, parallel radiating arms achieved which each can be tuned to different resonance frequencies as described above. Figure 6b disclose the arrangement in a more schematic view.

Figure 7a shows a variant of the fourth preferred embodiment where first and second top capacitance, 701 and 702 is coupled to the first and second radiating arms, 703 and 704. In figure 7b, the second radiating arm is an elongated conductive strip 705 and no top capacitances are used. In figure 7c, the first radiating arm 703 comprises a top capacitance 701 and in figure

7d, the second radiating arm 704 comprises a top capacitance 702.

Figure 8a shows a diagrammatic view according to a fifth preferred embodiment of the invention where three radiating arms are used. The arms are arranged in parallel and each radiating arm comprises inductive coupling. In figure 8b, the radiating arms are arranged in an Y-form, and in figure 8c, the arms are arranged in a T-form. Even though not shown, each individual radiating arm may or may not comprise a top capacitance to ground and even though each arm is shown comprising a inductive coupling, it is also possible to have individual arms as elongated conductive strips. Also the feeding is left out for sake of clarity as well as a possible short connecting the antenna to ground in figure 8b and 8c.

Figure 9a shows a diagrammatic view according to a fifth preferred embodiment of the invention where four radiating arms are used. The radiating arms are arranged in a cross form and each radiating arm comprises inductive coupling. In figure 9b the radiating arms are arranged in a H-form. Also in this embodiment is it possible to use elongated conductive strips and/or top capacitances.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

CLAIMS

1. A microstrip antenna structure for receiving and transmitting radio frequency signals, comprising
   - a ground plane means,
   - at least a first feeding means and,
   - N radiating elements where N is an integer number greater than zero,
   - c h a r a c t e r i z e d i n,
   - said microstrip antenna structure having a first conductive patch,
   - said feeding means being arranged for feeding radio frequency signals to said first patch,
   - at least a first of said N radiating elements having a second patch,
   - inductive means for inductively couple said second patch to said first patch and,
   - said second patch having a free end.

2. The structure according to claim 1 wherein,
   - said first and second patch being thin conductive layers on a dielectric carrier,
   - said ground plane means substantially coextending with said N radiating means being arranged in proximity to said patches.

3. The structure according to any of claims 1-2 wherein,
   - said second patch having a substantially rectangular shape.

4. The structure according to any of claims 1-3 wherein,
   - said first and second patch being arranged at a specific distance from each other to attain a capacitive coupling

between said first and second patch with a specific capacitance.

5. The structure according to any of claims 1-4 wherein,
- first capacitive means being arranged for capacitively couple said first patch to said second patch.

6. The structure according to any of claims 1-5 wherein,
- a retainer means being arranged for retaining at least one discrete component in electric contact with said first and second patch.

7. The structure according to any of claims 1-6 wherein,
- said dielectric substrate comprises at least a first and a second protrusion arranged for retaining at least one discrete component in electric contact with said first and second patch.

8. The structure according to any of claims 1-7 wherein,
- N is equal to one and,
- said first patch being substantially rectangular.

9. The structure according to any of claims 1-8 wherein,
- at least a second of said N radiating elements is an elongated conductive strip having a free end.

10. The structure according to any of claims 1-9 wherein,
- N is greater than one,
- said first conductive patch comprises at least a first protruding part,
- at least a second radiating element comprises a third substantially rectangular conductive patch,
- inductive means being arranged for inductively coupled said third patch to said first protruding part and,
- said third patch having a free end.

11. The structure according to any of claims 1-10 wherein,
   - at least one of said N radiating elements having a capacitive coupling to said ground plane means in said free end,
   - said capacitive coupling being adjusted to a specific capacitance.

12. The structure according to claim 11 wherein,
   - a conductive extension means extending towards said ground plane means so as to attain said capacitive coupling.

13. The structure according to claim 11 wherein,
   - said antenna structure further comprising a discrete component achieving said capacitive coupling.

14. The structure according to any of claims 1-13 wherein,
   - said inductive means is a meandering conductive strip.

15. The structure according to any of claims 1-13 wherein,
   - said inductive means is a coil.

16. The structure according to any of claims 1-13 wherein,
   - said inductive means is a tunable, active inductor.

17. The structure according to any of claims 1-16 wherein,
   - said N radiating elements being arranged substantially parallel.

18. The structure according to any of claims 1-16 wherein,
   - N being three,
   - said first patch having three protruding parts essentially forming a Y-shape and,
   - first, second and third radiating elements extending from said protruding parts.

19. The structure according to any of claims 1-16 wherein,
   - N being three,

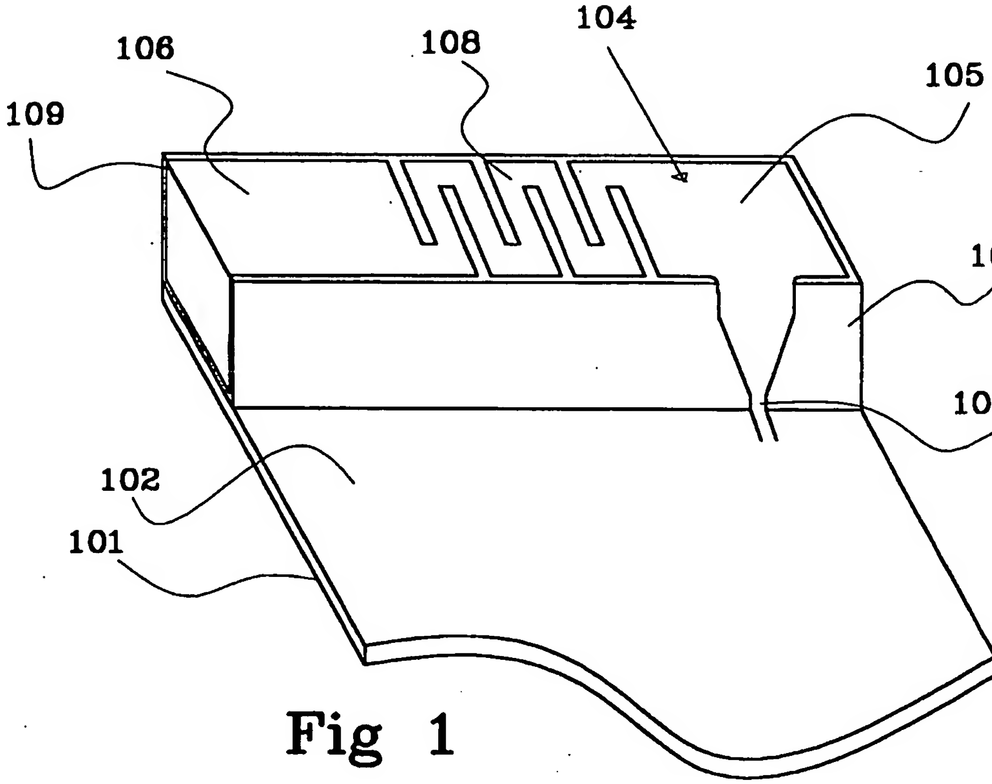
- said first patch having three protruding parts essentially forming a T-shape and,
- first, second and third radiating elements extending from said protruding parts.

20. The structure according to any of claims 1-16 wherein,
- N being three,
- first and second radiating elements extending essentially parallel in a first direction and,
- third radiating element extending in a opposite direction to said first direction.

21. The structure according to any of claims 1-16 wherein,
- N being four,
- said first patch having four protruding parts essentially forming a cross shape and,
- first, second, third and fourth radiating elements extending from said protruding parts.

22. The structure according to any of claims 1-16 wherein,
- N being four,
- said first patch having four protruding parts essentially forming a H-shape and,
- first, second, third and fourth radiating elements extending from said protruding parts.

23. The structure according to any of claims 1-22 wherein,
- coupling means being arranged for coupling said first patch to ground.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101

Fig 1

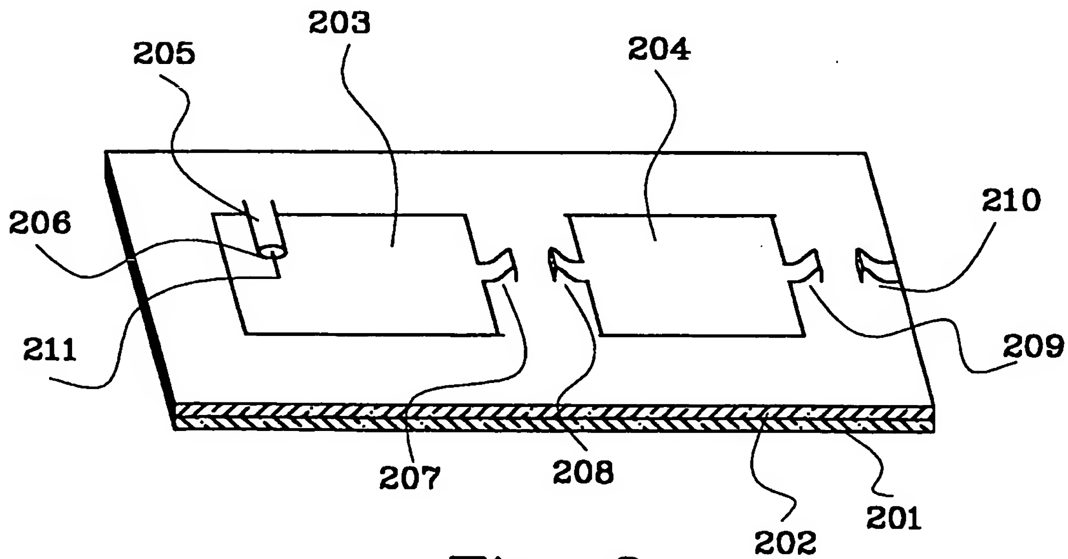
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Fig. 2

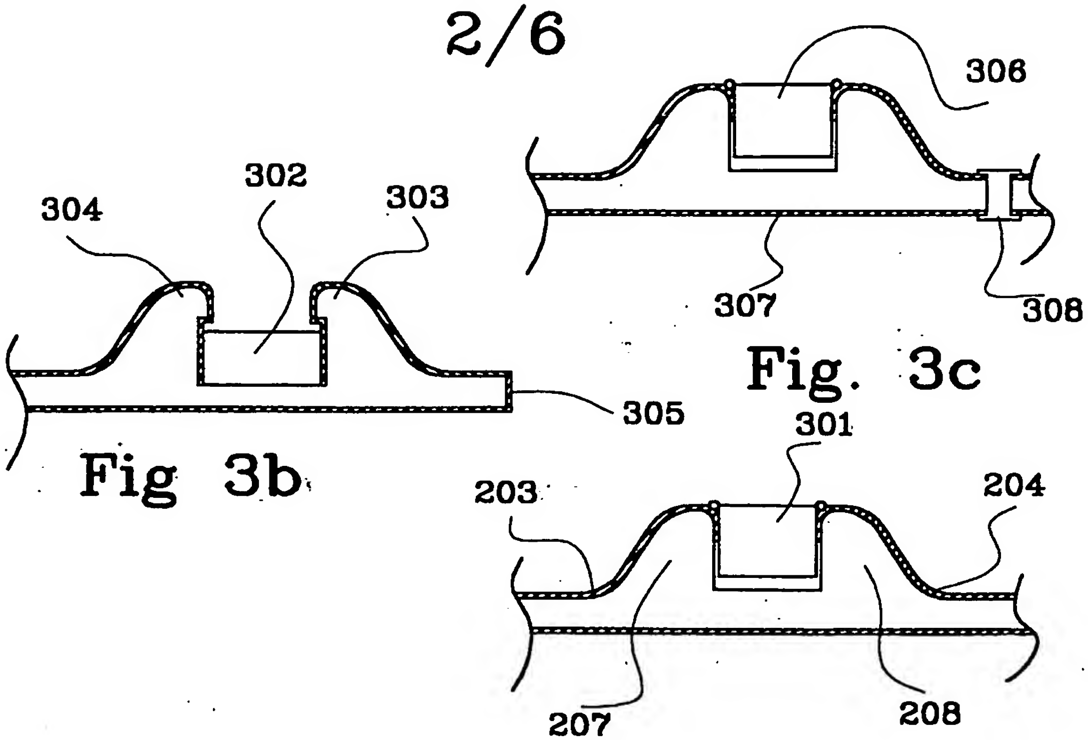

Fig 3b

Fig. 3c

Fig. 3a

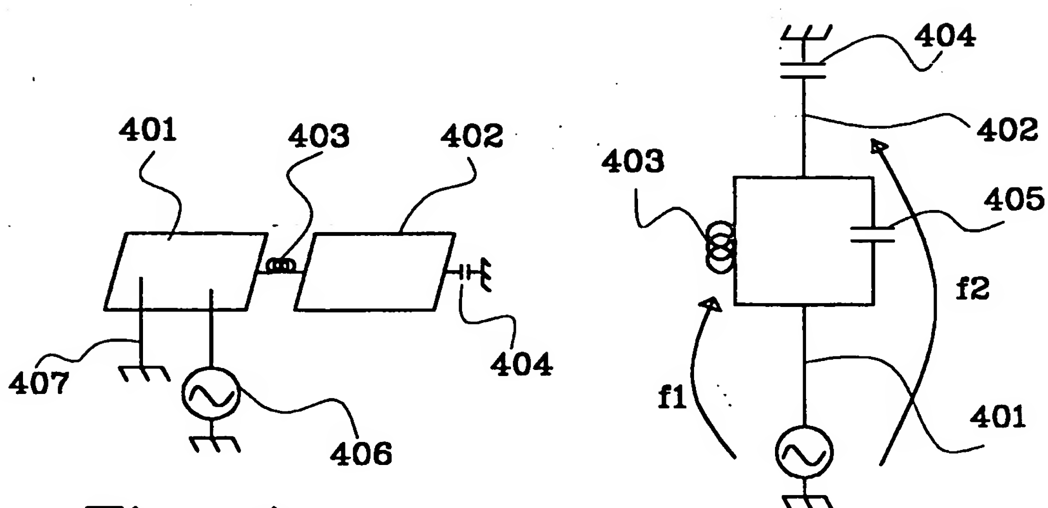

Fig. 4a

Fig.4b

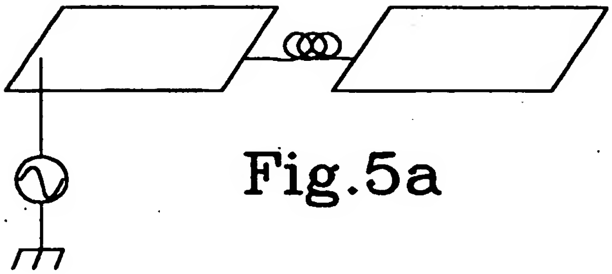

Fig.5a

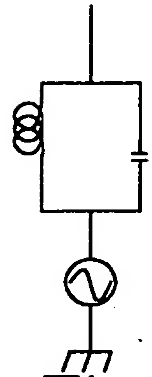

Fig.5b

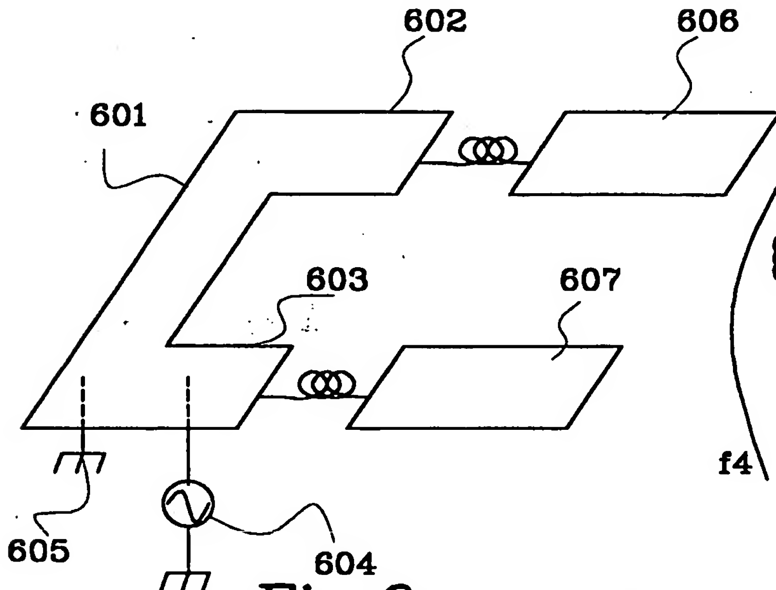

Fig.6a

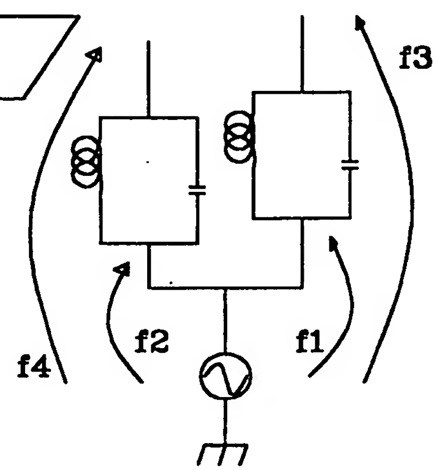

Fig.6b

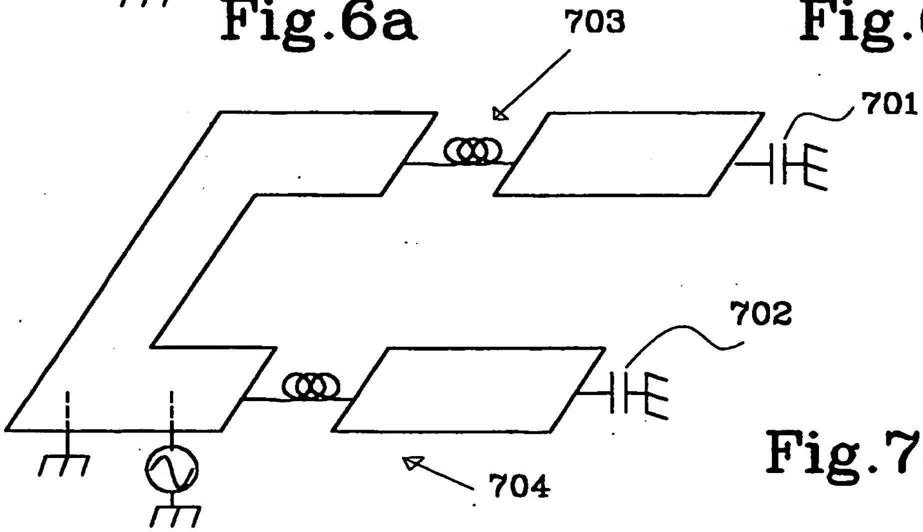

Fig.7a

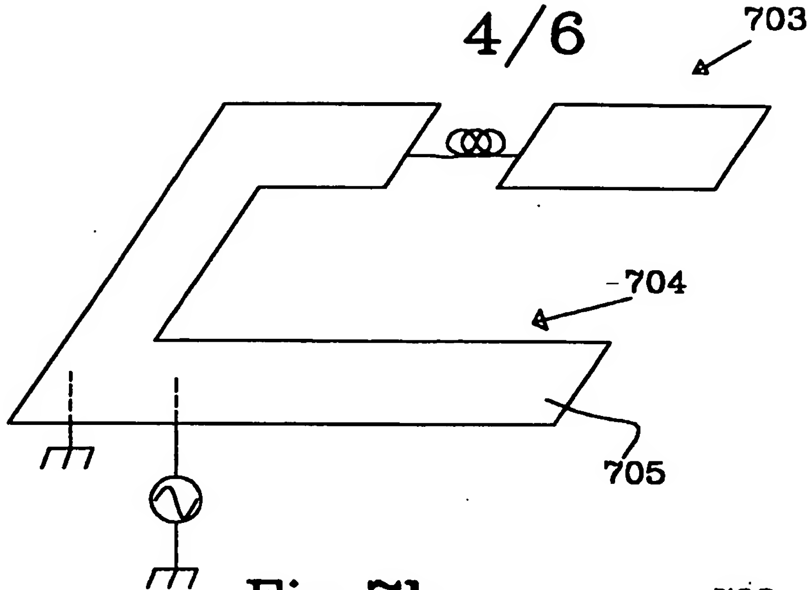

Fig.7b

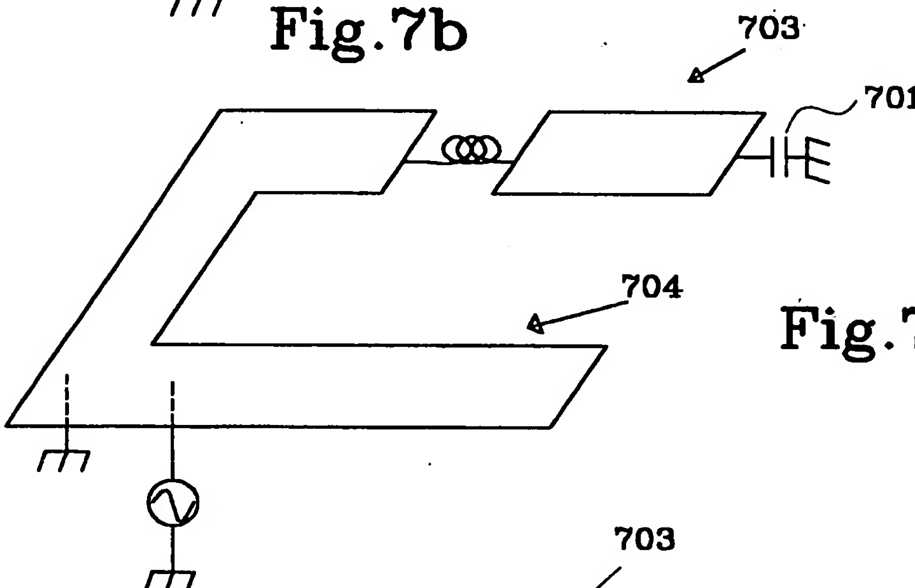

Fig.7c

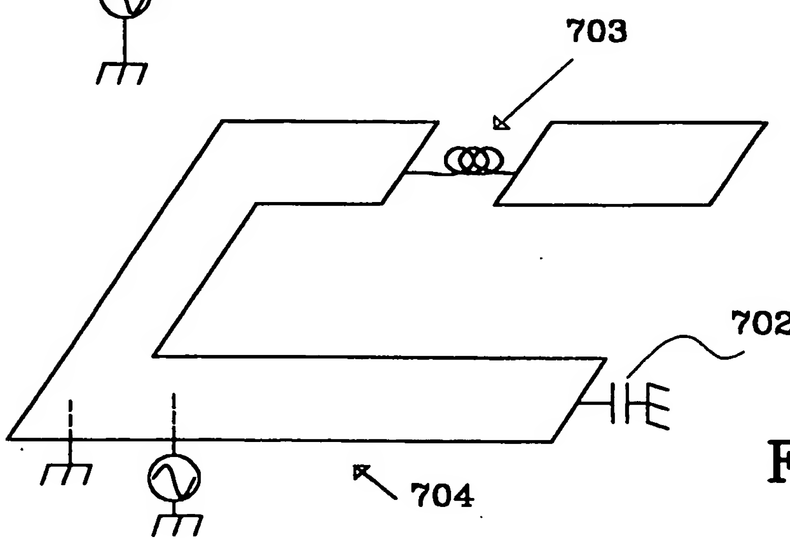

Fig.7d

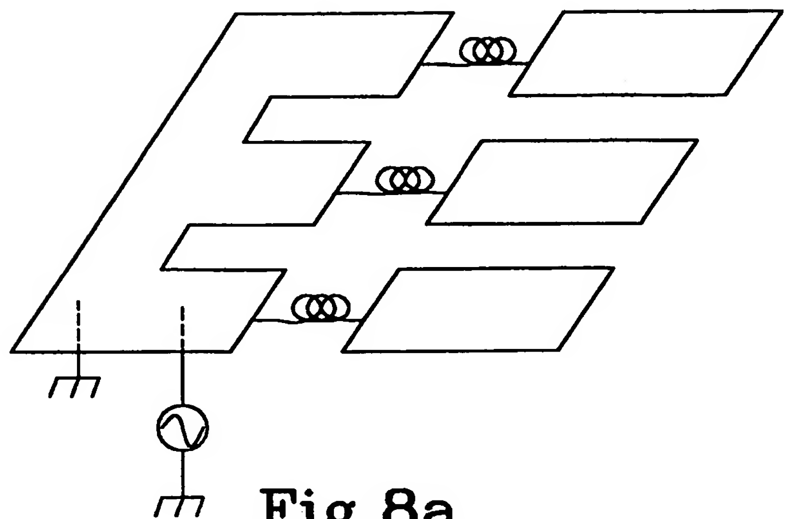

Fig.8a

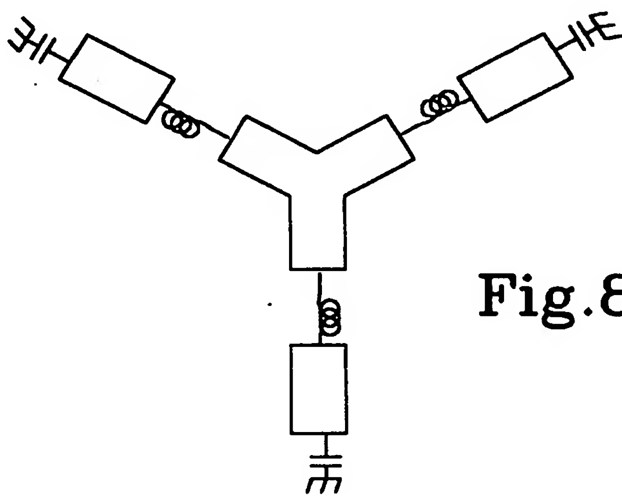

Fig.8b

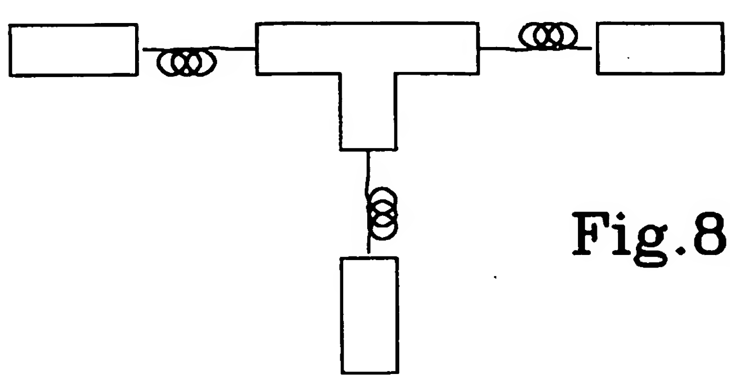

Fig.8c

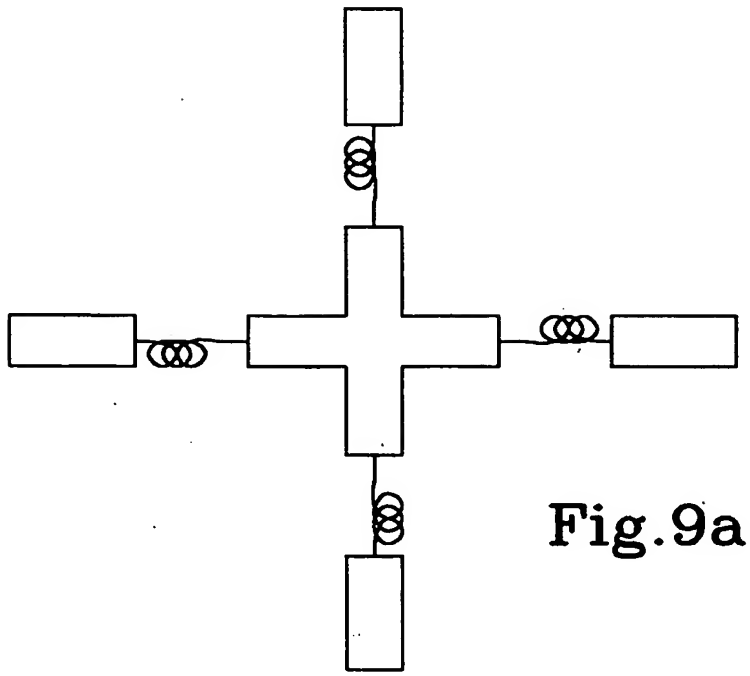

Fig.9a

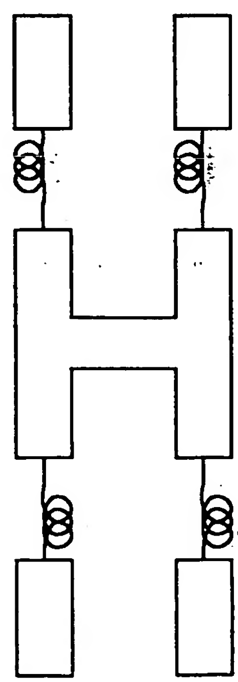

Fig.9b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01341

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01Q 1/24, H01Q 9/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0749176 A1 (NOKIA MOBILE PHONES LTD.), 18 December 1996 (18.12.96), cited in the application --	1-23
A	WO 9627219 A1 (THE CHINESE UNIVERSITY OF HONG KONG), 6 Sept 1996 (06.09.96), cited in the application -- --------	1-23

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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